AMERICAN SOCIETY OF HEATING, REFRIGERATING

AND AIR-CONDITIONING ENGINEERS, INC.

1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400

TC/TG/TRG MINUTES COVER SHEET

(Minutes of all meetings are to be distributed to all persons listed below

within 60 days following the meeting.)

TC/TG/TRG NO. TG4.SBS DATE: 19 May 1998

TC/TG/TRG TITLE: Smart Building Systems

DATE OF MEETING: 20 January 98 LOCATION: San Francisco

Members Present	Appt	Members Absent	Appt	Ex-Officio Members and Additional Attendance
George Kelly	96-98	Jeff Haberl	98-02	Osman Ahmed
John Mitchell	96-00	Mark Bailey (CM)	98-	Kenneth Bailey
Les Norford	96-98	Kirk Drees (CM)	96-	Dan Beebe
Steve Blanc	98-02	Ira Goldschmidt (CM)	98-	Michael Brambley
Jim Braun	96-00	J. Carlos Haiad (CM)	96-	Mark Breuker

Carol Lomonaco	96-99	Tim Ruchti (CM)	96-	Marty Burns
Arthur Dexter (int'l member)	96-00	Greg Schoenau (CM)	96-	Bill Carroll
Philip Haves (int'l member)	96-00	Peter Simmonds (CM)	98-	Natascha Castro
Rich Hackner	98-02			Ray Ching Chua
Barry Bridges	98-02			Pamela Darrah
James Gartner	98-02			Robert Dodier
Ron Kammerud	96-99			Jerry Doran
Michael Kintner-Meyer	98-02			Tom Engbring
Doug Nordham	96-98			Carol Gardner
Patrick O'Neill	96-99			Srinivas Katipamula
John Seem (CM)	96-00			Curt Klaassen

John House (CM)	96-			Jan Kreider
David Kahn (CM)	96-			Jim Kummer
Brian Kammers (CM)	96-			Hanjin Miao
Ron Nelson (CM)	98-			Bob Old
Jim Winston (CM)	96-			John Phelan
				Ofer Pittel
				Todd Rossi
				Jeff Rutt
				Kasim Sinnamohideen
				Pornsak Songkakul
				Dick Staley
				Gene Strehlow
				Meli Stylianou

				Tim Toenjes
				Brad Whitchall
				Steve Yang

DISTRIBUTION:

ALL MEMBERS OF TC/TG/TRG

TAC CHAIRMAN: Erv L. Bales

TAC SECTION HEAD: Jeffrey Biskup

ALL COMMITTEE LIASONS AS SHOWN ON TC/TG/TRG ROSTERS:

Program: Thomas D. Logan Manager Of Technical Services: Claire B. Ramspeck

Research: Carl F. Speich Manager Of Research: William W. Seaton

Standards: Waller S. Clements Manager Of Standards: Jim L. Heldenbrand

ADDITIONAL DISTRIBUTION: Visitors listed above

ASHRAE TC ACTIVITIES SHEET

DATE: 19 May 98

TG NO. TG4.SBS TC TITLE: Smart Building Systems

CHAIR: G. Kelly VICE CHAIR: J. Mitchell

TG Meeting Schedule

Location, past 12 mo.	Date	Location, next 12 mo.	Date

Boston	7/1//97	Toronto	6/24/98
San Francisco	1/20/98	Chicago	1/26/99

TG Subcommittees

Subcommittee	Chair
Fault Detection/Diagnosis	J. Seem
Applications	J. House
Utility/Building Interface	S. Blanc
Research	J. Braun
Program	C. Lomonaco

Research Projects

1011-RP Utility/EMCS Communication Protocol Requirements

1020-RP* Demonstration of Fault Detection and Diagnostic Methods in a Real Building

1043-RP* Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers

* Contractors were selected at January 1998 meeting

Long Range Research Plan and Additional Work Statements

Rank	Title	W/S Written ?	TG Approved ?	To RAC ?
1	Integrated Building Services - Performance and Performance Measurements	Yes	No	No
2	Distributed and Hierarchical Fault Detection and Diagnosis of HVAC Systems	Yes	No	No
3	Optimizing EMCS Architecture in BACnet Speaking Systems	No	No	No
4	Development and Evaluation of Fault Detection and Diagnostic Methods for Chillers	No	No	No
5	Development of Fault Detection and Diagnostics for Sensor Failures	No	No	No

1043-RP, the first-priority project when the LRRP was last submitted, has been removed from the LRRP.

Handbook Responsibilities - none

Standards Activities - none

Technical Papers from Sponsored Research - none

TG Sponsored Symposia (past 3 years, present, planned)

Title	Date

	(Given or Planned)
HVAC System Fault Detection And Diagnosis (Kelly)	Philadelphia, 1/97
Controlling Outdoor Air Ventilation for 62-1989 (Ganesh; TC 1.4 lead with TG4.SBS as co-sponsor)	Toronto, 6/98
FDD Using Real Building Data (Ahmed; TC4.11 lead with TC1.4 as co-sponsor)	Chicago, 1/99
FDD Methods and Evaluation (Castro)	Chicago, 1/99

TG Sponsored Seminars (past 3 years, present, planned)

Title	**Date** **(Given or Planned)**
The Utility/Building Interface: Redefining an Old Relationship (Blanc)	Boston, 6/97
BACnet in the Real World (Bushby; TC 1.4 lead with SSPC 135 BACnet and TG4.SBS as co-sponsors)	Boston, 6/97
Automated Response To Real Time Pricing (Kammerud)	San Francisco, 1/98
The Delivery of New Energy Services under Electric Industry Deregulation (Nordham; TC4.11 lead with TC 1.4 as co-sponsor)	San Francisco, 1/98

Benefits of Integrating HVAC with Non-HVAC Systems (Newman; TC 1.4 lead with SSPC 135 BACnet and TC4.11 as co-sponsors)	San Francisco, 1/98
Impact of Electromagnetic Interference on Control Systems and Global Standards (Coogan; TC 1.4 lead with TC4.11 and TC 1.9 as co-sponsors)	San Francisco, 1/98
New Platforms and Gateways for Connecting into Building Management Systems (Phelan)	Toronto, 6/98
The Latest Control Communications Technologies (Gartner; TC 1.4 lead with TG4.SBS as co-sponsor)	Toronto, 6/98
What is the Status of Smart Buildings and Where are They? (Lomonaco, TC4.11 lead with TC1.4 as co-sponsor)	Chicago, 1/99
Customers' Views of Deregulation (Claar)	Chicago, 1/99

TG Sponsored Forums (past 3 years, present, planned)

Title	**Date** **(Given or Planned)**
What Are The Priorities For On-Line HVAC Fault Detection And Diagnosis? (Haves)	Philadelphia, 1/97
Exactly What Do Smart Buildings and Control Systems Mean Today? (Newman and Kelly; TC 1.4 lead with TG4.SBS and TCs 1.5 and 4.6 as co-sponsors)	Boston, 6/97

Occupant Driven Interactive Building Control (Bridges; TG4.SBS lead with TC 1.4 as co-sponsor)	
Now That We Have the BACnet Standard Protocol, are DDC Programming Language and Application Standards Next? (Nesler; TC 1.4 lead with SPC 135 BACnet and TG4.SBS as co-sponsors)	San Francisco, 1/98
CAB and BACnet Similarities and Dissimilarities (Newman; TC 1.4 lead with SPC 135 BACnet and TG4.SBS as co-sponsors)	Toronto, 6/98

Journal Publications (past 3 years, present, planned)

Title	**When published**
None	

Minutes summary and activities sheet submitted by: Les Norford—TG4.SBS Secretary

TC4.11 Minutes

Tuesday, January 20, 1998 -- San Francisco

Roll Call, Introductions, Announcements

Chairman Kelly called the meeting to order at 3:35 p.m and asked for a roll call and introductions. Fifteen of 16 voting members were present: Kelly, Mitchell, Norford, Blanc, Braun, Lomonaco, Dexter, Haves, Hackner, Bridges, Gartner, Kammerud, Kinter-Meyer, Nordham, O'Neill.

Kelly noted that what was formerly TG4.SBS is now officially TC4.11. Kelly recognized Jeff Biskup, the TCA section head, and Carl Speich, the RAC research liason, both of whom expressed their interest in supporting the new TC. Speich noted that work statements for RAC action in March must reach Bill Seaton by February 15, 1998.

The agenda was distributed. The call to meeting and agenda are found in Appendix A. Kelly stated that the agenda as distributed would be changed to consider research at the end of the meeting, so that voting members of the TC could meet in executive session to consider recommendations for contractors for two TRPs. In accordance with ASHRAE policy, only voting members are permitted to consider these recommendations; by scheduling research at the end, corresponding members and guests can be excused and will not need to wait for contractor selection and later re-enter the meeting.

A motion was made (O'Neill) and seconded (Blanc) to accept the minutes from the July 1998 meeting. The motion was approved unanimously. Norford stated that minutes in the future would be made available in Adobe Acrobat format for those who cannot read Word files.

Kelly stated that the committee's subcommittees are active and need new participants to help out the old hands.

Fault Detection and Diagnosis Subcommittee Report (Seem)

Seem reviewed progress on work statements and new research ideas. The work statement **on Distributed and Hierarchical FDD of HVAC Systems**, Priority #2 on the TC long-range research plan (LRRP) and authored by Rossi and Brambley, needs a narrower scope and will be ready for TC vote at the Toronto meeting. A copy can be found in Appendix H of these minutes. Three new research ideas, not on the LRRP, were identified in the subcommittee meeting. Haves proposed a project on Whole Building FDD, which would involve CAD files, simulations with DOE-2 or a comparable package, and comparison of simulation with building operation. Haves will revise the first-draft WS for Toronto, with help from Kelly, Norford and Heinemeier. Breuker prepared a one-page description of a project for Development of Simple Equipment Models to Use with **a Model-Based FDD Technique on Vapor-Compression Equipment**. Rossi will assist Breuker in preparing a WS for Toronto. Breuker also prepared a one-page description of a **Survey of Operating Fault Levels in Vapor Compression Equipment**. Braun will help Breuker to prepare a WS for Toronto. Seem appealed for new ideas, with WS submitted in advance of meetings. Braun needs one-page project descriptions for the next LRRP, to be approved in Toronto.

For program activities, Ahmed is chairing a symposium on FDD with real-building data, to be held in Chicago in January 1999. Three papers are under review, with 1-2 more needed. The deadline for submittal of the final package to ASHRAE is August 7.

Seem shared Web addresses for FDD work:

Pacific Northwest National Lab (PNNL) Whole-Building Diagnostician http://www.buildings.pnl.gov:2080/wbd/

IEA Annex 34 Computer-aided Evaluation of HVAC System Performance: the Practical Application of Fault Detection and Diagnosis Techniques in Real Buildings

http://annex34.mets.nrcan.gc.ca

IFAC workshop on on-line fault detection and supervision in the chemical process industries, June 4-5, 1998, Lyon France

http://www.ifp.fr/CO/IN024GT2.html

Minutes of the subcommittee meeting are in Appendix B.

Applications (House)

House reviewed a work statement on **Integrated Building Services - Performance and Performance Measures (Research Priority Item #1)**. This intent of the work is to understand the costs and benefits of integration across major building systems, by surveying stakeholders and conducting field analysis. House requested comments by March 1 and will distribute a revised WS to TC members prior to Toronto. PMSC volunteers include Barker, Wilson and Rutt; Kintner-Meyer is also interested. TC4.6 has prepared a WS titled **Scoping Study: Load Aggregation for Buildings**. TC4.6 seeks TC4.11 co-sponsorship, and Kelly will conduct a letter ballot when the WS is approved, with the goal of meeting the February 15 submittal deadline. House volunteered to be the TC4.11 member of the PMSC; Braun, a member of TC4.11, will also be on the PMSC as a representative of TC4.6. House solicited ideas for programs at future meetings.

Blanc provided an update of the Philip Burton Federal Office Building project in San Francisco, a 1.4 million square foot office building and courthouse managed by GSA that is a demonstration site for a variety of energy-efficiency improvements, controls upgrades and BACnet communications. A tour was held on January 19, and installation of HVAC controls is nearly complete. Some corner offices are cold. Lighting controls and BACnet communications are functioning well. Follow-up phases for the project include a chiller upgrade.

Klaassen stated that the Iowa Energy Center (IEC) is interested in working (on a fee basis) with those desiring to demonstrate new HVAC technologies at the IEC.

Minutes of the subcommittee meeting are in Appendix C.

Utility/Building Interface (Blanc)

Blanc stated that progress on RP-1011 was reviewed with the contractor (SAIC/Hypertek). This project, titled **Utility/EMCS Communication Protocol Requirements**, requires that the contractor identify existing services and communication protocols, identify potential services, develop an object-oriented model for the exchange of information, and make suggestions to ASHRAE. The contractor provided substantial information to the PMSC and in turn received several suggestions, notably the need to provide an early draft of the final report. The contractor, which is off to a good start, will make a presentation to the TC at the Toronto meeting.

Blanc stated that the subcommittee may want to look at the effects on the distribution system of load shedding and restoration. He presented program

ideas for future meetings, including seminars on new metering services, rate structures and communications, and control of multiple buildings, as on campuses. As research topics, he put forward two topics: security issues for smart meters and a survey of what people want to know about buildings, in the context of energy services.

The minutes of the subcommittee meeting are in Appendix D.

Program Subcommittee (Lomonaco)

Lomonaco praised the program at this meeting, which included two well-attended seminars and a forum. The program for Toronto and Chicago is included in the summary sheet at the beginning of the minutes and the Program Subcommittee Report in Appendix E. It was moved (Lomonaco) and seconded (O'Neill) that TC4.11 approve the program for Toronto, which includes one seminar with TC4.11 as the lead sponsor, **New Platforms and Gateways for Connecting into Building Management Systems**, and one forum, **Load Aggregation**. The motion passed via a unanimous voice vote. Looking ahead to Chicago, TC 4.11 plans two symposia (**FDD Using Real Building Data** and **FDD Methods and Evaluation**) and two seminars (**What is the Status of Smart Buildings and Where are They?** and **Customers' Views of Deregulation**), ranked as listed.

The minutes of the subcommittee meeting are in Appendix E.

Roster

The roster for the July 1, 1998 - June 30, 1999 ASHRAE year was submitted by Kelly on January 7, prior to the San Francisco meeting. Braun will be the new chair and Kelly will chair the research subcommittee. The remaining positions will be announced later.

New Business

Kelly noted that TC4.7 has its own home page on the Web and that TC4.11 would also benefit from a home page, for current and archived minutes.. A TC must provide its own host site and maintain it. ASHRAE approves a proposed site and home page format and provides a link to ASHRAE's home page. Lomonaco, Rossi, Phelan and Stylianou will explore possible site. ASHRAE may provide TC home pages in the future and is now considering security issues, including who is authorized to write to Web sites and whether work statements under development should be visible to any reader. Kelly announced that at ASHRAE Headquarters Ramspeck will replace Heldenbrand as Director of Standards, leaving an opening for Director of Technical Services.

Research Subcommittee (Braun)

Braun distributed a summary of the TC's current LRRP, new research ideas, and opportunities for WS co-sponsorship (Appendix G; the LRRP is also in the summary sheet at the beginning of the minutes). Work statements are nearly complete for projects designated as Research Priorities 1 and 2. There is no progress on Research Priority #3. Research Priority #4 is a follow-on project to RP-1043, for which a contractor will be selected at this meeting, and Research Priority #5 was proposed by Haberl, who is absent. Research topics are needed for utility-customer interfaces and not solely FDD.

In executive session for voting members only, the TC voted to recommend to RAC contractors for TRP-1020 and TRP-1043.

Adjourn

Motion to adjourn was made by O'Neill and seconded by Bridges. The meeting was adjourned at 5:33 p.m.

Addenda

Subsequent to the meeting, TC4.11 voted to co-sponsor the TC4.6 WS **Scoping Study: Load Aggregation for Buildings**, by a vote of 13-0-1, chair voting.

Subsequent to the meeting, the forum on Load Aggregation was scrubbed due to a lack of support.

Appendices

A. Call to Meeting and Agenda
B. FDD Subcommittee Report
C. Applications Subcommittee Report
D. Building/Utility Interface Subcommittee Report
E. Program Subcommittee Report
F. List of Subcommittee Attendees
G. Research Activities

H. Distributed and Hierarchical FDD of HVAC Systems

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

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Reply to: George E. Kelly

Room B114 Bldg. 226

NIST

Gaithersburg, MD 20899

(George.Kelly@nist.gov)

December 8, 1997

Dear TC 4.11 (TG4.SBS) Member,

International Member,

Corresponding Member, or

Visitors to the TG Meeting in Boston

Congratulations! You are now a member/participant in a new Technical Committee! The ASHRAE TAC voted at their meeting in October to convert TG4.SBS to TC 4.11 and to keep the Title, Scope, and description of Activities unchanged.

The **TC** on Smart Building Systems and its subcommittees will meet in San Francisco according to the following schedule:

TC 4.11 Fault Det. & Diagnostic Sub. Sunday (1/18) 2:30-3:30pm

TC 4.11 Applications Sub. Sunday (1/18) 3:30-4:30pm

TC 4.11 Utility/Bldg. Interface Sub. Sunday (1/18) 4:30-5:30pm

TC 4.11 Program Sub. Sunday (1/18) 5:30-6:30pm

TC 4.11 Smart Building Systems Tuesday (1/20) 3:30-5:30pm

Please consult your ASHRAE Program Booklet for meeting place locations. Also, **please note that the full TC meeting will again be on Tuesday**.

We currently have **two** Tentative Research Projects out for bid. They are:

1020-TRP, Demonstration of Fault Detection and Diagnostic Methods in a Real Building , and

1043-TRP, Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools for Chillers .

With luck, we should be in a position to select a contractor for each of these Tentative Research Projects at our San Francisco meeting.

The TC is the lead sponsor of three program sessions in San Francisco that I encourage all of you to attend. They are:

Seminar 4, **Automated Response to Real Time Pricing**

10:15 a.m. - 12:15 p.m., Sunday 1/18 (See ASHRAE Program Booklet for meeting location.)

Seminar 18, **The Delivery of New Energy Services Under Electric Industry Deregulation**

8:00 a.m. - 10:00 a.m., Monday 1/19 (See ASHRAE Program Booklet for meeting location.)

Forum 42, **Occupant Driven Interactive Building Control**

9:00 a.m. - 9:50 a.m., Wednesday 1/21 (See ASHRAE Program Booklet for meeting location.)

In addition, the TC is cosponsoring a number of other technical program sessions with several other Technical Committees.

Below is a draft agenda for the full TC 4.11 committee meeting in San Francisco. Please come prepared to: participate in one or more of the subcommittee meetings, discuss the different draft Research Work Statements, accept responsibility for developing new work statements, and help plan future program sessions for Toronto and beyond. As I mentioned at previous meetings, participation is the key to staying/becoming a voting member.

I am looking forward to seeing you in San Francisco.

Sincerely,

George E. Kelly

Chairman, TC 4.11

cc: Erv Bales, TAC Chairman

Jeffery Biskup, TAC Section 4 Head

Carl Speich, R&T Research Liaison

Claire Ramspeck, Manager of Technical Services

Bill Seaton, Manager of Research

ASHRAE TC 4.11

Smart Building Systems

1998 Winter Meeting, San Francisco

DRAFT AGENDA

Location: (See ASHRAE Program Booklet for meeting location.)

Date: Tuesday, January 20, 1998

Time: 3:30 - 5:30 p.m.

1. Roll call and introductions

2. Approval of Minutes from Boston

3. Announcements

4. FDD Subcommittee Report (John Seem)

Draft Work Statements

Program plans

IEA Annex 34 update

Other FDD research activities

5. SBS Applications Subcommittee Report (John House)

Draft Work Statements

Program plans

Philip Burton Office Building update

Iowa Energy Center update

Other possible demonstration sites

6. Utility/Bldg. Interface Subcommittee Report (Steve Blanc)

TRP - 1011, Utility/EMCS Communication Protocol Requirements (Les Norford)

Draft Work Statements

Program plans

Real time pricing/Deregulation update

7. Research Subcommittee Report (Jim Braun)

1020-TRP, Demonstration of Fault Detection and Diagnostic Methods in a Real

Building (John House)

1043-TRP, Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools

for Chillers (John Seem)

Work Statements

8. Program Subcommittee Report (Carol Lomonaco)

Plans for Toronto (6/98)

Plans for Chicago (1/99)

Plans for Seattle (6/99)

Plans for future meetings

9. TC 4.11 1999 Draft Roster

10. Additional old business

11. Additional new business

12. Adjournment

Appendix B.

TC4.11 Fault Detection and Diagnostics Subcommittee Meeting

Minutes

San Francisco: January 18, 1998

1. The first item of business was a discussion of a draft work statement entitled "Distributed and Hierarchical Fault Detection and Diagnostics of HVAC Systems." The work statement was co-authored by Todd Rossi and Mike Brambley. Todd provided a summary of the work statement, which concentrates on the development of a "Coordinator" to integrate information obtained from independent FDD methods. Discussion centered around the timing of the work in relation to the state-of-the-art for FDD in HVAC systems. In particular, it was thought that additional experience is needed with FDD in real applications before an effort is made to determine what the capabilities the "Coordinator" should have. The consensus was that the scope of the work should be narrowed and emphasis removed from the "Coordinator" aspect of the work. Todd and Mike will revise the work statement for Toronto.

2. The second item of business was a discussion of a draft work statement entitled "Whole Building Fault Detection and Diagnosis." The work statement was authored by Phil Haves. Phil provided a summary of the work statement, which entails the development of an energy simulation tool that could be used for building commissioning. Energy use computed by the simulation tool would be compared with commissioning results, and differences would be assumed to be due to faults in the building HVAC systems. The operation of the building systems would then be assessed and if faults were not identified, the simulation tool would be recalibrated. The ensuing discussion raised several issues, including whether a calibrated building model could be used for FDD throughout the lifetime of the building. Les Norford and George Kelly will assist Phil with revising the work statement for Toronto.

3. Mark Breuker introduced two ideas for work statements. The first idea dealt with the development of simple equipment models to use with model-based FDD techniques for vapor compression equipment. Gray-box and empirical models were possibilities that Mark described. There was some discussion about the use of empirical models in light of the fact that they are only reliable over the range of operation for which they are trained. Todd Rossi volunteered to assist Mark to develop this idea into a draft work statement. Mark suggested that models that could be trained "on-line" would be the most practical type to implement in the field and should be the focus of the research. Todd Lash from Landis & Staefa indicated that they were doing some work in a related field for chiller diagnostics and would also be willing to help define the work statement.

4. The second idea concerned the need for a survey of operating fault levels in vapor compression equipment. This work would focus on a field assessment of the typical levels of operating faults such as refrigerant leakage and exchanger fouling and the quantification of their impact on equipment energy efficiency. The results could be used in the justification for the development of FDD tools for these systems. Jim Braun agreed to assist Mark in the development of a draft work statement.

4. John Seem discussed FDD related Web sites and encouraged anyone with knowledge of other sites to make them known to members and participants of TC 4.11.

Submitted by:

John House

Appendix C.

TC4.11 Applications Subcommittee Meeting

Minutes

San Francisco: January 18, 1998

1. The first item of business was a discussion of a draft work statement entitled "Integrated Control for Building Services." The work statement was co-authored by Ron Kammerud and John Mitchell. Ron provided a summary of the work statement, which includes an assessment of the state of the art for integrating building services, examines costs and benefits associated with integration, identifies characteristics indicative of effective integration, and makes recommendations for research related to integrated services. The work statement is almost completed, but needs adequate consideration by committee members. Comments should be directed to John House by March 15, 1998. John will incorporate comments with input from Ron and John Mitchell and will send the revised work statement out to voting members prior to the Toronto meeting. Kim Barker, John Wilson, and Jeff Rutt volunteer to serve on the project monitoring subcommittee.

2. The second item of business was a discussion of a draft work statement entitled "Scoping Study: Operation Dynamics Of Aggregates Of Buildings." The work statement was authored by Ron Kammerud. Ron provided a summary of the work statement and emphasized the need to move forward with this work or the industry would move beyond us. The ensuing discussion seemed to indicate a need for public domain tools that perform "intelligent" selections of buildings to aggregate. Mike Brandemuehl discussed the TC 4.6 perspective and offered to take the lead on revising the work statement to emphasize tools needed for aggregation.

3. The third item of business was a discussion of potential program ideas. Future seminars related to real-time-pricing and the 450 Golden Gate demonstration were discussed but no actions were taken.

Submitted by:

Todd Rossi and John House

Appendix D.

TC4.11 Building/Utility Interface Subcommittee Meeting

Minutes

San Francisco: January 18, 1998

Agenda

1. Review and Approval of Goals of the Sub Committee:

The Building / utility Interface sub committee will develop research and communicate findings and developments in the following areas:

- Customer vendor relationships and related subjects such as:
  - The energy /services marketplace
  - Energy Efficiency services
  - Other services, their provision and relationship to HVAC and energy use.
- Systems Integration from an intra- and inter-facility perspective including :
  - Building Systems including HVAC, lighting, process (computers and restaurants for example), transport and Fire and Life Safety
  - On site energy generation, delivery and / or storage control / monitoring
  - Facility aggregation

Further, we intend to explore the following issues and their impacts:

- Protocols for building systems communication and utility information systems.
- Information transfer – process of, content of
- Where is the building vendor interface? And where is it going?
- How can the building / vendor interface be automated.

2. **Program Ideas and Support:**

At this meeting:

Seminar 4, **Automated Response to Real Time Pricing**

10:15 a.m. - 12:15 p.m., Sunday 1/18 (See ASHRAE Program Booklet for meeting location.)

Seminar 18, **The Delivery of New Energy Services Under Electric Industry Deregulation**

8:00 a.m. - 10:00 a.m., Monday 1/19 (See ASHRAE Program Booklet for meeting location.)

Forum 42, **Occupant Driven Interactive Building Control**

9:00 a.m. - 9:50 a.m., Wednesday 1/21 (See ASHRAE Program Booklet for meeting location.)

Agenda:

see attached for the proposed programs

Given the list, do we have any new ideas for program?

3. Research – Please refer to the list attached - any new ideas ? volunteers?
4. New Business – whats going on out there with Building Utility interfaces? Anything we can bring to ASHRAE?

Meeting Minutes

1. Goals of Subcommittee: Chair read the goals of the subcommittee and asked for comment and approval. Several comments were voiced: R.Hackner – "Goals should encompass local distribution rather than just local buildings". This provoked discussion on theis point. Comments: " Deal with secondary effects of third party relationships." Customer/vendor/utility. "Need to deal with smart buildings → smart campus → smart distribution systems"

   The goal addition suggested was: - Load shedding and restoration impacts on customer, vendor and distribution systems. With this addition, the subcommittee agreed on goals.

2. Program:

The chair and sub reviewed the present and projected programs for 4.11 and suggested the following:

1. Seminar: New metering and service entrance services and designs. Action: Frank Olken and Marty Burns "volunteered" to put on a seminar at Toronto.
2. Seminar: Communications and other issues dealing with Life Safety and Fire systems [I think I got this wrong, if anyone has it right please get back to me] SB Action: None taken
3. Seminar: Control of multiple buildings or campus complexes (This needs someone from industry). Action: None taken [I later contacted Mike Newman about this, he is going to try to get back to me with some names for speakers. If we can find four to five this could go at Chicago. SB]
4. Seminar: Session on RTP sites and controls Action: Kammerud will do a survey of potential sites, Kummer volunteered to help.
5. The customer view of RTP controls / gateways. One example would be the West Bend Mutual Insurance HQ in Wisconsin. Issues:

   Metering and control of residential systems, potential gateway systems

   Metering and control of commercial systems, potential gateway systems

   The crossover of residential and commercial applications and systems

   Would involve CEBus, BACnet, Echelon Action: Contacts possible from Marty Burns, Carol Lomonaco later asked Rosenthal to coordinate this for Seattle.

3. Research

The chair and subcommittee reviewed the 7/1/1997 list of proposed research projects.

Marty Burns introduced the following topic:

1. Security issues for encryption and authentication when clients interact over WANS through gateways to LANs to access shared devices. Eg. Multiple utilities using a device that monitors pulses on separate utility meters. All utilities have some private information and shared information in the single device.

   Another idea was:

2. What kinds of information do vendors want to know about buildings? What's valuable to brokers / vendors / aggregators? What should customers give vendors? [Check Michael Kinter-Mayer's work]

Perhaps some innovative and ambitious soul can take these and do a one pager for Toronto?

4. New Business (new ideas, news and gossip about Utility Building Interface issues and the odd ASHRAE related issue…)

M. Burns: Cellnet doing statewide cell system for utility communication.

F Olken: At CORBA utility object definition electrical distribution . what about load shedding? Vendors/ control vendors / few utilities involved. These efforts are overlapping:

1. Kansas City Electricial Utility (Kansas City Power and Light?)
2. EPRI projects, IEC(?)
3. OMG

They want to talk to buildings, and are creating object definitions for building components

Functional Area needing information sharing

M Burns: EPRI is developing a modular meter w/ "video game cartridge" . Cash register vs. enhanced services modes of operation. Telemetry / BMS plugs on to meter. Interfaced with anything

JPhelan AEC: They have a new platform with database polling. PC Gateway / platform for applications. Informa diagnostic system running as part of the PNNL / Battelle WBD

Seminar Idea: Gateways for EMS to the outside… what's happening?

See you all in Toronto Sunday, June 21, 1998 5:00PM somewhere in Toronto .

The amended goals read as:

The Building / utility Interface sub committee will develop research and communicate findings and developments in the following areas:

- *Customer vendor relationships and related subjects such as:*
  - *The energy /services marketplace*
  - *Energy Efficiency services*
  - *Other services, their provision and relationship to HVAC and energy use.*
- *Systems Integration from an intra- and inter-facility perspective including :*

- *Building Systems including HVAC, lighting, process (computers and restaurants for example), transport and Fire and Life Safety*
- *On site energy generation, delivery and / or storage control / monitoring*
- *Facility aggregation*
- *Load shedding and restoration impacts on customer, vendor and distribution systems.*

Further, we intend to explore the following issues and their impacts:

- *Protocols for building systems communication and utility information systems.*
- *Information transfer – process of, content of*
- *Where is the building vendor interface? And where is it going?*
- *How can the building / vendor interface be automated.*

Listing of attendees:

Name	Company / Affiliation	Email address
Steve Blanc	PG&E	Slb4@pge.com
Ron Kammerud	Paradigm Consulting	Kammerud@ix.netcom.com
Carol Lomonaco	JCI	Carol.Lomonaco@JCI.com
Les Norford	MIT	LNorford@MIT.edu
George Kelly	NIST	George.Kelly@NIST.gov
Rich Hackner	ECW	Rhackner@ecw.org

John House	NIST	John.House@NIST.gov
Patrick O'Neill	Honeywell	Patrick.Oneill@HBC.Honeywell.com
Mark Breuker	Carrier	Breuker@mcione.com
Todd Rossi	FDS	Rossi@acrx.com
Jim Braun	Purdue	Jbraun@ecu.purdue.edu
Frank Olken	LBNL	Olken@lbl.gov
John Wilson	TS	Yowilson@juno.com
Jeff Rutt	USDOD	none
Natascha Castro	NIST	Natascha.Castro@NIST.gov
Mike Brandemuehl	Univ. Colorado	Michael.brandemuehl@Colorado.edu
Jim McNally	Landis and Staefa	Jim.McNally@us.landisstaefa.com
Kimberly Barker	Landis and Staefa	Kimberly.Barker@us.landisstaefa.com
Curtis Klaasen	Iowa Energy Center	Curtk@energy.iastate.com

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John Phelan	AEC	Jphelan@archenergy.com
Barry Bridges	Univ of Minn.	Bbridges@forestry.umn.edu
Doug Nordham	R.W. Beck	Dnordham@RWBeck.com
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Marty Burns	Hypertek, Inc.	
Jim Kummer	JCI	James.p.kummer@jci.com
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Pornsak Songkakul	Landis and Staefa	Pornsak.songkakul@us.landisstaefa.us.com
Tom Engbring	APS	Tengbrin@apsc.com

Appendix E.

TC4.11 PROGRAM SUBCOMMITTEE

With Updates from the TC4.11 Meeting

JANUARY 20, 1998, REVISION 1.0

Program Chair: Carol Lomonaco

The program was reviewed and approved at Tuesday's TC4.11 general meeting (aka TG4.SBS). The TC prioritized the programs for Toronto and Chicago. An updated program plan will up submitted for the next three meetings and sent into ASHRAE Headquarters.

The Program subcommittee meeting was called to order at 5:30 pm on Sunday, January 18, 1998 and ended at 6:00 pm.

Attendees were:

Carol Lomonaco Les Norford George Kelly John House

Mark Brueker Todd Rossi Marty Burns Mike Brambley

Carlos Haiad Doug Nordham Barry Bridges Ron Nelson

John Phelan S. Katipamula Curtis Klaasser Jim McNally

Steve Yang Jeff Rutt John Wilson Hanjin Mias

Ray Ching Chua Frank Olken

Programs for Toronto, Chicago, Seattle and the future were discussed. Each of the four sections for each of the future meetings is listed below. However, at the time of the Program meeting titles and co-sponsorship for each of the meetings were not verified. Two additional seminars were

discussed outside the program subcommittee meeting, they are: 1) Individual Controls: A Smart Building Approach and 2) Facility Managers' (IFMA) View of Deregulation.

Revised Forums, Seminars, and Symposia packages were picked up before the general TC meeting and were distributed at the general meeting.

I. PROGRAMS PROPOSED FOR THE MEETING IN TORONTO, JUNE 20-24, 1998 (listed in order of priority as voted on 1/20/98 at TC meeting)

1. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

Load Aggregation

Forum, Frank Olken & Ron Kammerud

2. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

New Platforms and Gateways for Connecting into Building Management Systems

Seminar, John Phelan

3. Sponsoring Committee: TC1.4 & Co-Sponsoring Committee: BACnet & TC4.11

CAB and BACnet Similarities and Dissimilarities

Forum, Mike Newman

4. Sponsoring, Committee: TC1.4 & Co-Sponsoring Committee: TC4.11

The Latest Control Communications Technologies

Seminar, Jim Gartner

5. Sponsoring, Committee: TC1.4 & Co-Sponsoring Committee: TC4.11

Controlling Outdoor Air Ventilation for 62-1989 Revisions

Symposium, Gaylen Atkinson

II. PROGRAMS PROPOSED FOR THE MEETNG IN CHICAGO, JANUARY 23-27, 1999 (listed in order of priority as voted on 1/20/98 at TC meeting)

1. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

Fault Detection Diagnostics (FDD) Using Real Building Data

Symposium, Osman Ahmed

2. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

FDD Methods and Evaluation

Symposium, George Kelly & Natascha Castro

3. Sponsoring Committee: TC4.11 & Co-Sponsoring Committee:

Global View of Deregulation…reporting on several states.

Seminar, Charles Clarre (IFMA) & Jim Yi (Jim Yi contact Shikori & Lauret.)

4. Sponsoring Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

What Is the; Status of Smart Buildings and Where Are They? Asia? Europe? NA?

Seminar, Michael Kintner-Meyer & Carol Lomonaco

5. Sponsoring, Committee: TC1.2 & TC1.4 & BACnet & Co-Sponsoring Committee: TC4.11

Updates on Motors, and Intelligent Actuators + Sensors

Seminar, Rick Eiden and/or Gaylen Atkenson

6. Sponsoring Committee: TC1.4 & Co-Sponsoring Committee: TC4.11 and BACnet

The Value of Pre-BACnet Control Integration Experience in the New Millennium Buidling Performance

Seminar, Steve Bushby

7. Sponsoring Committee: TC1.4, 1.7, 9.9 & Co-Sponsoring Committee: TC4.11

Owner/Operating Engineers Commissioning O and M Problems and Solutions with BAS and FDD

Seminar, Michael Newman

8. Sponsoring Committee: TC1.4, 9.9& Co-Sponsoring Committee: TC4.11

Who Really Setermines Tomorrow's Building Indoor Environment Comfort, IAQ and Productivity-Designers, Installers or Operators

Forum or Seminar, James Gartner

III. PROGRAMS PROPOSED FOR THE MEETING IN SEATTLE, JUNE 19-23, 1999 (Not Prioritized)

1. Sponsoring' Committee: TC4.11 & Co-Sponsoring Committee:

What's ASHRAE's Role in Deregulation?

Forum, Steve Blanc

2. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

RTP, A look at Real Buildings Using RTP. Impacts that Have Been Observed.

Symposium, Jim Kummer & Ron Kammerud

3. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

Residential Smart Controls

Seminar, Rosenthal

4. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

Individual Controls. A Smart Building Approach.

Seminar, Lomonaco

5. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

A Peek at a Real BACnetTM Building…GSA 450 Golden Gate BACnet Pilot Project

Seminar, Steve Blanc

6. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

Metering Issues and Realities in the World of Deregulation.

Seminar, Frank Olken & Jim McNally

7. Sponsoring, Committee: TC4.11 & Co-Sponsoring Committee:

Alternate Communications…Powerline Carrier and Others.

Seminar, Barry Bridges

IV. PROPOSED FURTURE PROGRAM SUBJECTS (Not Prioritized)

1. Sponsoring Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

What Is the Definition of a Smart Building System? (Some Countries Have

a Different Definition of What a Smart Building Is.)

Forum or Seminar, George Kelly and Jim Yi

2. Sponsoring Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

Deregulation and Energy Efficiency in the United States? Energy Efficient Independent Board

Seminar, Les Norford & Carlos Haiad

3. Sponsoring Committee: TC4.11 & Co-Sponsoring Committee: TC1.4

Case Studies of RTP and Aggregation in Maine, Massachusetts and WALMART & HOME DEPOT

Seminar, Les Norford, Steve Blanc, John Phelan & Doug Nordham

Appendix F.

List of Subcommittee Attendees

Name	FDD	Applications	Building/Utility Interface	Program
George Kelly	x	x	x	x
Les Norford	x	x	x	x
Steve Blanc			x	

Jim Braun	x	x	x	
Carol Lomonaco	x	x	x	x
Arthur Dexter	x	x	x	
Philip Haves	x			
Rich Hackner	x	x	x	
Barry Bridges		x	x	x
Ron Kammerud	x	x	x	
Doug Nordham	x	x	x	x
Patrick O'Neill		x	x	
John Seem	x	x		
John House	x	x	x	x
J. Carlos Haiad		x	x	x

Ron Nelson	x	x		x
Kimberly Barker		x	x	
Dan Beebe	x			
Mike Brambley	x		x	x
Mike Brandemuehl		x	x	
Mark Breuker	x	x	x	x
Marty Burns		x	x	x
Natascha Castro	x	x	x	
Ray Ching Chua			x	x
Tom Engbring			x	
Barrett Flake	x			
Ellen Franconi	x			

Kristin Heinemeier	x			
Robert Jacobs	x	x		
Srinivas Katipamula	x	x	x	x
Richard Kelso	x			
Curt Klaassen	x	x	x	x
Jim Kummer			x	
Todd Lash	x			
Scott LeClair	x			
Jim McNally			x	x
Hanjin Miao	x	x	x	x
Frank Olken			x	x
Dick Perry	x			

John Phelan	x	x	x	x
Todd Rossi	x	x	x	x
Jeff Rutt	x	x	x	x
Mario Seneviratne	x			
Pornsak Songkakul			x	
Meli Stylianou	x	x		
Michael Wetter		x		
John Wilson		x	x	x
Steve Yang				x

Appendix G.

Research Activities

1. **Current Research Projects**

   1011-RP - Utility/EMCS Communication Protocol Requirements

2. **Projects Awarded at San Francisco**

   1020-TRP - Demonstration of Fault Detection and Diagnostic Methods in Real Buildings

   1043-TRP - Fault Detection & Diagnostic Requirements & Evaluation Tools for Chillers

3. **97-98 Research Plan**

Project	Contributors	Status
1. Integrated Control for Building Services	R. Kammerud J. Mitchell John House	3rd draft of workstatement
2. Distributed and Hierarchical Fault Detection and Diagnosis of HVAC Systems	Todd Rossi Mike Brambly	2nd draft of workstatement
3. Optimizing EMCS Arichitecture in BACnet Speaking Systems	G. Kelly	one page description
4. Development and Evaluation of Fault Detection and Diagnostic Methods for Chillers	J. Braun A. Dexter	one page description

5. Development of Fault Detection and Diagnostics for Sensor Failures	J. Haberl	one page description

4. New Research Ideas

Project	Contributors	Status
1. Whole Building Fault Detection and Diagnostics	Phil Haves Les Norford	1st draft of workstatement
2. Development of Simple Equipment Models to Use with Model-Based FDD Technique on Vapor Compression Equipment	Mark Breuker Todd Rossi	one page description
3. Survey of Operating Fault Levels in Vapor Compression Equipment	Mark Breuker Jim Braun	one page description

5. Co-Sponsorship Opportunities

Project	Contributors	Status

1. Scoping Study: Load Aggregation for Buildings	Ron Kammerud	TC 4.6 mail ballot by 2/15

Appendix H.

Draft Work Statement

TITLE

Distributed and Hierarchical Fault Detection and Diagnostics of HVAC systems

BACKGROUND

Large systems, including buildings, can be represented in a hierarchical structure where the entire system is divided into sub-systems, which is in turn are divided into sub-sub-systems, etc., as illustrated in Figure 1.

Figure 1 – Hierarchical structure of a building's HVAC system

Fault detection and diagnostic (FDD) methods can operate on one or more levels throughout this hierarchical structure. In this context, fault detection identifies a malfunction within one of the blocks in the system and diagnostics further determines which sub-system(s) under that block are not working properly.

"Fault models" and "sub-system isolation" are two broad categories of FDD methods. Fault models diagnose faults in sub-systems by hypothesizing how the faults affect large scale measurements on the block as a whole. Sub-system isolation identifies faults by using enough measurements to decouple a sub-block from the rest of the structure sufficiently to isolate and determine its performance. Diagnosing faults in vapor compression cycles provides a good example of fault modeling because it is difficult to make enough measurements to isolate the performance of each component in the cycle (refrigerant flow rate and refrigerant state measurements being especially difficult). Isolating a building's hot/chilled water plant from the distribution system provides and equally good example of sub-system isolation because the hot/chilled water plant interacts with the rest of the system in a limited and easily quantifiable manner through the production of hot and cold water.

The objective of this research is to investigate distributed and hierarchical FDD systems for HVAC equipment. Such systems promise to provide the greatest benefits for large systems (e.g., all the HVAC equipment in a 40 story building) that need the hierarchical structure to divide the system into manageable components, but the hierarchical structure could be applied to smaller buildings and may be of value in the diagnostic process itself. This work statement further focuses on solutions that utilize distributed computing (i.e., processing takes place at multiple locations distributed throughout the building and/or control system). This is common in large building systems that use DDC controls in sub-systems throughout a building. A distributed FDD system analyzes the performance of various sub-systems in their local controller and communicates decisions to trigger actions. Sending individual measurements from throughout a building to an operator workstation for analysis is an alternative approach.

Dividing a large system into a hierarchical structure is the first step in this process. It is important to id ıentify sub-systems that will be somewhat isolated from each other. These will usually fall along the lines of distributed control computing already being established in buildings. More specifically, sub-system controllers divided by network connections can probably be isolated from each other and diagnostics within a single controller will probably use some level of fault modeling.

Subsystems, however, have interactions (consider, for example, the chilled water temperature that is produced by the chiller and used by cooling coils). This, along with uncertainty in measured conditions, creates the potential for overlapping and conflicting results from FDD systems applied to different HVAC subsystems. For example, the chiller FDD might call for a warmer chilled water temperature, while some of the cooling coils it serves call for a lower chilled water temperature. For a building operator to use advice from these distributed, independent FDD systems, some coordination of their results is needed. If conflicts occur between FDD systems, they need to be resolved. This role can be met by a supervisor/coordinator system

that operates on or at the level of building operator's workstation. In addition, this supervisor/coordinator can serve as the interface to provide FDD results to the user in a useful form.

This project focuses on demonstrating interaction between distributed FDD systems in a hierarchical system and the user of a supervisor/coordinator to coordinate their results to provide meaningful information to building operators.

JUSTIFICATION

Fault detection and diagnostic (FDD) techniques are emerging from research and are beginning to be tested in real buildings. Many of these techniques focus on specific HVAC subsystems or components of them; others operate at the whole-building level to identify performance anomalies and identify subsystems causing the anomalies. At the same time, control functions are becoming more distributed with much control processing (computing) taking place at the device or subsystem level, rather than at a central (building-level) location. This provides opportunities for the use of distributed FDD in conjunction with distributed control, yet creates the need to coordinate and resolve conflicts between diagnostic results produced by different FDD systems. This research project responds to that need by providing information that will be needed by the HVAC professions to successfully apply distributed FDD in large buildings by demonstrating how a supervisor/coordinator can integrate the results from such systems to provide meaningful information to building operators.

OBJECTIVE

The objective of this research project is to define, develop and demonstrate a system for supervising/coordinating interactions among a human user and distributed, hierarchical, FDD systems in a real building. In addition, the project will identify and document issues that need to be resolved before such systems are widely implemented. The results will provide guidance for future research and application of FDD technology for HVAC systems.

Some of the issues to be addressed will include (but are not limited to):

1. sharing data among multiple FDD systems—providing a database schema and database that accommodates a model of the entire building, provides for the data needs of FDD modules for specific building sub-systems, sub-subsystems, and components, and that can be readily extended to meet the unique data needs of additional FDD modules while maintaining database integrity;
2. resolving multiple opinions about the same problem when two FDD modules provide different, potentially conflicting, results;
3. enabling a user (e.g., building operator) to easily interact with multiple FDD modules;
4. techniques for entering, storing, and using models and expert knowledge about building system interactions and integration.

SCOPE

The project is divided into nine major tasks that the successful contractor is expected to perform:

1. Literature Survey
2. Develop the Building System Model and Database Schema
3. Select the Demonstration Building
4. Identify and Select Individual Subsystems, FDD Methods, and Faults
5. Design the Supervisor/Coordinator
6. Implement and install the Supervisor/Coordinator and FDD Methods
7. Test the Supervisor/Coordinator
8. Demonstration of the Supervisor/Coordinator
9. Final Report

Task 1 – Literature Survey

A literature survey shall be conducted to identify existing methods for supervising and coordinating the interactions of multiple hierarchically related FDD or other software modules and associated issues.

Task 2 – Develop the Building System Model and Database Schema

The contractor shall develop a general, hierarchical model and corresponding data schema that describes (or has the capability to accommodate descriptions) of large buildings, their systems, subsystems, subsubsystems, etc. down to the level at which any FDD system might operate. For example, this must include a way to represent building zones, HVAC systems, equipment, controllers, sensors, actuators, their characteristics and functions. The data schema should provide accommodations for any number of systems and their component subsystems and be filled for the specific building, systems and equipment selected for demonstration in this project. The PMS, before proceeding to subsequent tasks, will approve this model and data schema.

1. A building system model is an information system model that can be used to develop a database structure for describing buildings, their HVAC equipment, and their controllers. For example, it may have a way of representing all the HVAC equipment, sensors, zones, and controllers. Describe the model that will be used to organize all the information needed to describe the building.
2. Describe the hierarchical nature of the building model.
3. Describe how generally applicable the model is.

Task 3 – Select the Demonstration Building

The contractor shall select a building for demonstration and obtain approval of the building by the PMS. The building should have a central HVAC

system, with many (or several) air handling units, many (or several) zones, and have sub-system controllers with or suitable for implementing FDD methods. The subsystems for which FDD methods are implemented must be available and suitable for implementing faults. The PMS shall approve the selection.

1. Use the building model to describe the selected building.
2. Implement the model using a database system that can be used by the coordinator to provide context for interpreting data and alarms from the controllers. Specify how the user will interact with the database.

Task 4 – Identify and Select Individual Subsystems, FDD Methods, and Faults

In this task, the contractor shall select individual building systems, FDD methods that will be applied to them, and the faults that the methods will be capable of detecting and diagnosing. This task shall involve the following steps:

1. Identify two or three sub-systems of the building that will be used for demonstration in this research project. These systems must be distinct from one another but sufficiently related that faults can occur (or be instigated) that impact both systems simultaneously in such a way that FDD methods applied to both of them would produce related (and in some cases, possibly contradictory) results. These sub-systems might be at different levels in the building hierarchy. An example might be a air handler and the filter-coil section of it.
2. Individual FDD methods will be implemented for the selected HVAC subsystems (e.g., air handling units, chillers, and zone controllers) or subsections of them (e.g., filter coil section) in or linked to control products. Identify how the faults detected and diagnosed by the FDD methods for these systems interact with one another. Also, identify potential conflicts between the results obtained from these FDD methods, and how they would occur or could be instigated.
3. Identify what information the FDD methods will require, what information they will provide, and how FDD methods for each sub-system will interact with the coordinator in the operator workstation (i.e., inputs and /outputs).
4. Specify how these FDD systems overlap or interact. Resolving inconsistencies where FDD methods interact will be an important part of this research project. For example, an AHU controller could complain that the inlet chilled water is too warm. A chiller's controller could also have an opinion on this issue that may or may not agree.
5. Identify the FDD methods to be used on these sub-systems. It is not the intention of this research project to develop new FDD methods. Contractors are encouraged to use existing FDD methods. Buildings and systems with FDD methods already installed (or applied) can be proposed by the contractor.
6. The PMS will review and approve the selected HVAC subsystems, the FDD methods selected, and the interactions selected for demonstration.

Task 5 – Design the Supervisor/Coordinator

Development of the supervisor/coordinator will consists of two primary components: design (this task) and implementation (Task 6). The design shall

be approved by the PMS before implementation in software.

The contractor shall develop a design for the coordinator/supervisor. This design should describe in detail all intended functions of the coordinator, how they will be implemented (i.e., the methods used to implement), all communication and interactions with sources of data (user input, databases, sensors, controllers, building management systems), how results from the FDD methods will be presented to users, and how conflicts between FDD methods (or modules) will be resolved. The design should also identify and describe the specific FDD methods that will be implemented in the demonstration.

Some specific issues that need to be addressed in the design include:

1. Selection of a programming environment for implementing the coordinator (C++, JAVA, Visual Basic, etc.). Specify the range of operating systems it will run under (Windows NT, Windows 95, UNIX, etc.).
2. How the coordinator will communicate with controllers throughout the building. Will it be used to share data between controllers or FDD modules? If so, how?
3. How the coordinator interacts with users. Can it run over a network? Can multiple users work with it simultaneously?
4. How the coordinator will use the information from the controllers and sensors, in the context of the building model, to help the user manage the building's HVAC equipment. Describe how expert knowledge or fundamental principles will be entered, stored, and used by the coordinator (e.g., expert knowledge may be embedded in the program code or stored in a database).
5. How the coordinator will present information from the FDD methods. In addition to a general description, specifically refer to the FDD methods used in the demonstration.
6. How the coordinator integrates various FDD methods with special attention to where the FDD methods interact. How with the coordinator presents and resolves differences (or conflicts) between the FDD methods where they interact?
7. Modularity of the software so it can be easily revised and reused.

Task 6 - Implement and install the Supervisor/Coordinator and FDD Methods

The contractor shall implement the design from Task 5 in software in this task and install it in the selected demonstration building. The product of this task shall be a fully implemented supervisor/coordinator system installed in the test building and the FDD methods (or modules) implemented on the selected HVAC subsystems. The contractor shall verify that all functions specified in the design are operational.

Task 7 – Test the Supervisor/Coordinator

The contractor shall investigate the faults identified in Task 4 and verify the system's ability to reconcile results from multiple FDD methods. All tests must be carefully described so they could be reproduced and the results documented.

Task 8 – Demonstration of the Supervisor/Coordinator

The contractor shall develop a demonstration of the supervisor/coordinator that demonstrates the functions that it provides, prepare documentation that describes how the supervisor coordinator works and provides instructions for use its use, and deliver a copy of an off-line demonstration on disk or CD. Off-line demonstration could be accomplished using data stored in a database that corresponds to sensor or control-system data recorded during actual operation or using one or more computer programs to simulate the building systems. The contractor should also consider providing on-line demonstrations using the real building that may be viewed from off-site.

Task 9 – Final Report

The contractor shall prepare a comprehensive final report that describes all aspects and contributions developed in this project, including:

- the building and HVAC subsystems selected,
- the FDD methods, the faults they identify, and how they are implemented,
- detailed description of the building system model, the database schema, and its application in the demonstration,
- detailed design of the supervisor/coordinator
- implementation of the supervisor coordinator, including source code,
- descriptions and results of all tests,
- and a description and instructions for use of the demonstration.

The report should also identify and document problems and issues that need to be resolved before widespread deployment of hierarchical large building FDD systems is possible.

DELIVERABLES

The contractor shall develop and submit the following items as deliverables for this research project:

a. A literature review that summarizes existing methods for supervising and coordinating the interactions of multiple, hierarchically-related, FDD methods or other software modules and associated issues.

b. A recommendation for the demonstration building, including a description of the building, its HVAC and control systems and equipment, FDD methods already implemented, availability and suitability for instigating faults, and rationale for its selection.
c. A general, hierarchical model and corresponding database schema that can be used to describe the characteristics and behavior of a large building of arbitrary size, its systems, subsystems, subsubsystems, etc. that will be used for the demonstration supervisor/coordinator system.
d. A detailed design for the supervisor/coordinator developed for demonstration purposes in this project.

e. Source code for the supervisor/coordinator and any FDD methods developed or implemented as part of this project.
f. Final stand-alone demonstration on disk or CD illustrating the functionality of the supervisor/coordinator. This deliverable shall be ready for reproduction and distribution by ASHRAE.
g. Monthly teleconferences to address project progress with the PMS. These teleconferences shall be initiated by the Contractor's Principal Investigator and should include all members of the PMS. Minutes of the teleconferences shall be kept by the Contractor and distributed to all members of the PMS at the conclusion of each teleconference.
h. Written Progress and Financial Reports shall be made to ASHRAE through its Manager of Research at quarterly intervals – specifically on or before January 1, April 1, June 1, and October 1 of the contract period.
i. The Principal Investigator shall report in person to ASHRAE Technical Committee (TC) 4.11 at the Annual and Winter ASHRAE meetings and answer questions regarding the project as may arise.
j. A Final Report shall be prepared and submitted to the Manager of Research at the end of the contract period. This Report shall provide complete details of all research carried out on the project. Six (6) copies of the draft Final Report and demonstration product (disk or CD) shall be furnished for review by the Project Monitoring Subcommittee.
k. Following approval by the Project Monitoring Subcommittee and TC 4.11, final copies of the Final Report and demonstration product shall be furnished as follows:

- Six (6) copies of an Executive Summary of the project suitable for wide distribution to the industry and the public;
- Six (6) bound copies of the Final Report;
- One unbound copy of the Final Report, printed on one side only, suitable for reproduction;
- Four (4) 3.5" diskettes with copies of the Final Report -- two (2) with the Report in ASCII format and two (2) with the Report in the most current version of Microsoft Word or Corel WordPerfect;
- Six (6) copies of the final demonstration product on CD or 3.5" diskettes;
- A "master" copy of the CD or diskette for the demonstration product suitable for reproduction.

l. One or more Technical Papers shall be submitted in a form suitable for presentation at a Society meeting. The papers shall conform to ASHRAE's "Submitting Manuscripts for ASHRAE Transactions" which may be obtained from the Special Publication s Section. (On the ASHRAE Home Page, these guidelines are titled "Meeting Paper Preparation" and can be found under "How to Participate."
m. All papers or articles submitted for inclusion in ASHRAE publications that result from this research project shall be submitted through the Manager of Research — not directly to the publication's editor.
n. A Technical Article suitable for publication in the *ASHRAE Journal* may be requested by the TC or *Journal* Editor. Such an article would be considered a voluntary contribution to the profession and is not a project deliverable.

LEVEL OF EFFORT

The project is expected to require approximately 18 months to complete at a cost of about $100,000.

OTHER INFORMATION FOR BIDDERS

1. Bidders are expected to demonstrate a familiarity with published work related to this study and provide evidence of previous research that they have performed in the area of FDD for HVAC systems.

REFERENCES

AUTHORS

Todd Rossi

Michael Brambley

Phil Haves

Notes

Basic Concepts

1. The project will focus on a coordinator, running on an operator workstation, for multiple distributed FDD methods (implemented on controllers on a network). The coordinator will focus on integrating distributed FDD methods and investigate emerging issues.
2. The coordinator will contain expert knowledge for coordinating the FDD methods that will, for example, resolve conflicts where they interact.
3. A database is needed to describe specific facilities. The more generic expert system will use this database to focus its knowledge on specific cases.
4. The coordinator may be a good platform for sharing common data (e.g. ambient temperature) that multiple FDD methods on a network may need. This is more of a product development issue, instead of a more fundamental research issue, and is at best an interesting side benefit of this research project.

Scope Reduction

1. Specifying the FDD methods and perhaps their interactions is one possibility.
2. Another way is to start by taking the smaller step of investigating the phenomena of the interactions themselves (e.g., identify potential interactions, characterize them, propose solutions to them). Such a project might be followed later by one that focuses on demonstrating a supervisor / coordinator as a method for handling them (or some other approach).

3. Eliminate the real building and use simulations.